Short Segment Posterior Instrumentation with Intermediate Screw in Thoracolumbar Junction Injury: Prospective Study

Karam Fawaz Aldarzi* , Walid W. Al-Rawi**

ABSTRACT:

BACKGROUND:

Thoracolumbar fractures are traditionally treated surgically by short segment fixation; however, they may be associated with high implant failure. The insertion of an additional screw at fracture site makes it more stable with a better clinical outcome.

OBJECTIVE:

The aim was to evaluate the radiological and clinical parameters of posterior short segment fixation with intermediate screw implantation into the fractured vertebra.

METHODS:

We evaluated 30 patients with unstable thoracolumbar fractures, managed with short segment posterior instrumentation with intermediate screw in the fractured vertebra; fractures classification was done according to AOspine and TLICS systems . Eighteen male and 12 females qualified for the study; male to female ratio was 1.5:1; average age 28.86 years. Neurological status was classified according to the ASIA impairment scale. Pain was evaluated by VAS score. The percentage of vertebral body collapse and segmental kyphosis were assessed by Cobb method. Duration of follow-up lasted for 12 months.

RESULTS:

The mean preoperative VAS score was 8.55, had significantly improved to 0.87 at final follow up. Preoperative mean vertebral body collapse was 48.40%, which had significantly improved to 12.85% at final follow up. Mean segmental kyphotic angle was 21.83° before surgery, final mean segmental kyphosis was 8.63°. Fifteen patients with incomplete neurologic deficits had improvement by at least one ASIA grade on final follow-up observation, and 2 of 4 patients with complete neurologic deficit remained unchanged. All neurologically intact patients remained unchanged. None of patients had implant failure.

CONCLUSION:

Short segment fixation with intermediate screws in treatment of thoracolumbar junction fracture effectively improve stability with most of patients achieve significant improvement in clinical outcomes.

KEYWORDS: Thoracolumbar injury, Short segment fixation, Intermediate screw, Transpedicular screw.

INTRODUCTION:

The thoracolumbar junction (T10-L2) is abiomechanical transition zone prone to injury because of an inherent susceptibility to the kinetic energy transfer from the stiff, rostral thoracic spine to the relatively more flexible, caudal lumbar spine.[1]

The most common mechanisms of injury are those of a high-velocity pattern; these include motor vehicle collisions, falls, occupational injuries, and wartime related injuries.[2] High-velocity bony injuries carry an additional 25% risk for accompanying spinal cord injury (SCI) and 30% risk for intra-abdominal injury.[3]

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Further complicating this problem is the estimated rate of 50% of concomitant neurological injury that is associated with these fractures.[4] Classification systems, like the American Spinal Injury Association (ASIA)[5] Impairment Scale and Visual Analogue scale (VAS)[6], aid in standardizing patients for prospective studies with more homogenous patient populations to improve the quality of research (Tables 1, Figure 1). The extent of canal compromise and morphology of the thoracolumbar fracture type, presence of a neurological deficit, and radiographic findings that constitute a stable thoracolumbar spine are three major areas of confusion that play a major role in the newest classification system in use, the thoracolumbar Injury classification and severity score (TLICS), a classification system put forward by the Spinal Trauma Study Group (Table 2).[7] In 2013, the TLICS was further expanded and developed into a newer AO (Arbeitsgemeinschaft für Osteosynthesefragen) Spine thoracolumbar spine injury classification system(figure2).[8]

The aim of this prospective study was to evaluate the clinical and radiological outcomes of unstable thoracolumbar fractures treated with posterior short segment fixation including the fractured vertebra, which were followed-up for one year.

Table 1:American Spinal Injury Association (ASIA) Impairment Scale as Modified from Frankel Classification.

Scale level	Description
A	Complete: No sensory or motor function is preserved in sacral segments S4-5.
B	Incomplete: Sensory, but not motor, function is preserved below the neurological level and extends through sacral segments S4-5.
C	Incomplete: Sensory and motor functions are preserved below the neurological level. Most key muscles below the neurological level have a muscle grade of <3.
D	Incomplete: Sensory and motor functions are preserved below the neurological level have A muscle grade of >3.
E	Normal: Sensory and motor functions are normal

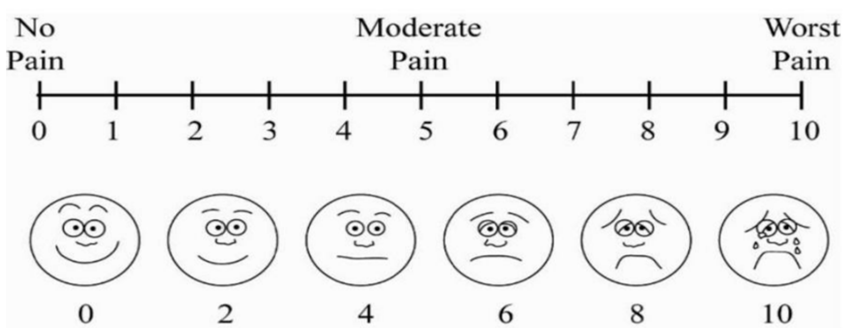


Figure 1. Visual Analogue scale (VAS).

Table 2: Thoracolumbar Injury Classification System.

Classification system	Type	Description	points
Thoracolumbar Injury Classification score (≥4 is suggestive of a need for posterior column restoration	1. Injury mechanism	Compression	1
		Translation	3
		Rotation	4
	2. Posterior ligamentous complex disruption	Intact	0
		Suspicion for / indeterminate	2
		Injured	4
	3. Neurological status	Nerve root involvement	2
		Cord involvement (incomplete)	3
		Cord involvement (complete)	2
		Cauda equine involvement	2

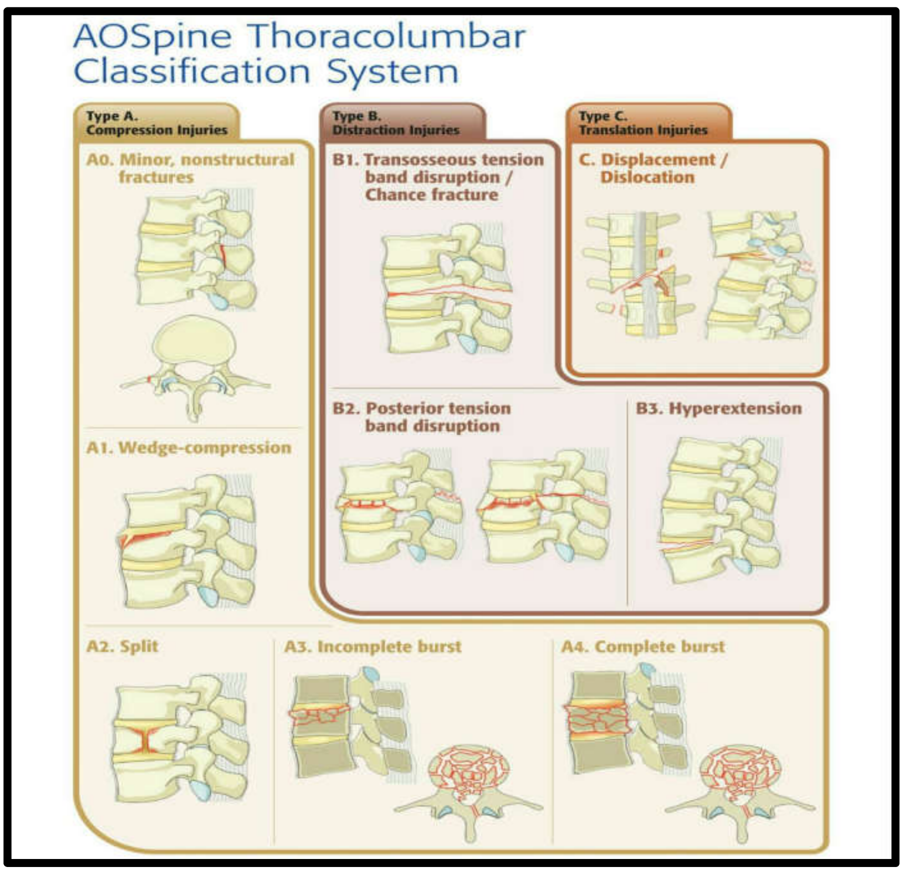


Figure 2 : AOspine classification system.

RadiologicalParameters

Vertebral body collapse (VBC) was defined as the percentage of fractured vertebral body compression with respect to the next adjacent intact vertebrae, above and below the fractured vertebra using the method of Mumford.[9] Segmental kyphosis was determined by measuring the Cobb angle[10] (Figures 3 and 4). These parameters were taken at the time of admission, immediate postoperative,three months post operation and final follow up after one year.

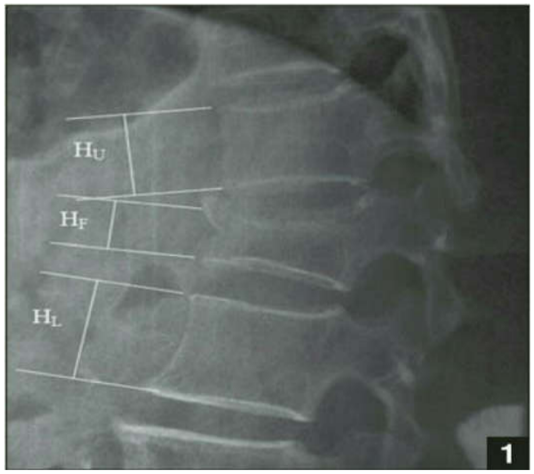


Figure:3

Figure 3. Radiograph showing the percentage of vertebral body collapse. The measured anterior height of the fractured vertebra was defined as the height of the fractured vertebra (HF). The mean value of the sum of the height of the vertebrae above (HU) and below (HL) the fractured vertebra was defined as the normal height of the fractured vertebra. Vertebral body collapse was defined as the height of fractured vertebra divided by the normal height of the fractured vertebra and expressed as a percentage. **VBC % = HF / {(HU + HL)/2} × 100** (ORTHOSuperSite.com, Monosegmental horacolumbar Fractures, TIAN et al, AUGUST 2011, Volume 34, Number 8).

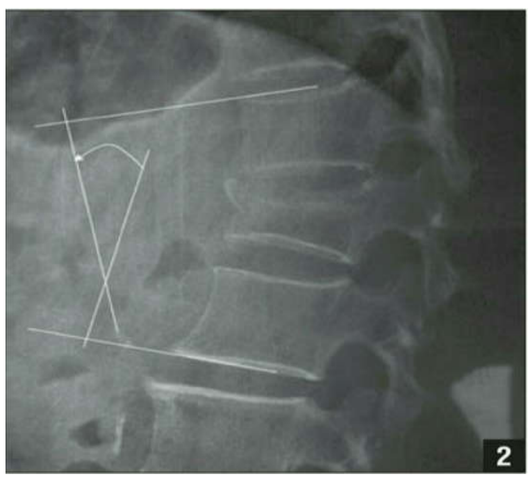


Figure 4

Figure 4. Radiograph showing the segmental kyphotic angle (Cobb angle). The kyphotic angle of the affected segments was defined as the measured angle between the superior end plate of the upper vertebra and the inferior end plate of the lower vertebra. (ORTHOSuperSite.com, Monosegmental Thoracolumbar Fractures, TIAN et al, AUGUST 2011, Volume 34, Number 8)

PATIENTS AND METHODS:

This prospective study was conducted at The Accident and Emergency Hospital (Teaching), Duhok City, between January 2016 and January 2018, in which we evaluated 30 patients with unstable monosegmental thoracolumbar junction fractures, managed with short segment posterior fixation; including the fracture vertebra. Eighteen male and 12 female patients, whose age ranged between 15 to 57 years, average age 28.86 years (SD ±13), qualified for the study. The inclusion criteria were:

- A single unstable thoracolumbar junction fracture (TLICS > 4), with neurologic deficits.
- AO spine type A3, A4 (compression injury), with or without posterior ligamentous complex injuries.
- AO spine type B1 , B2 (destruction injury).
- Fractures with vertebral body collapse exceeding 50% and/or segmental kyphosis exceeding 20°.

The following were the exclusion criteria:

- AO spine type C (translation injury).
- Fracture treated non – operatively, such as, stable, simple wedge fractures and fractures with TLICS < 4.
- Fractures surgically treated with short segment fixation without screw at the fracture site or with long segment fixation.
- Osteoporotic fractures.
- Multilevel spinal fractures.

Following resuscitation history taking, and clinical examination, patients had radiological studies which included plain X-ray, CT and MR/M scans, with or without contrast. Neurological status was classified according to American Spinal Injury Association impairment scale (Table 1) and pain was evaluated by Visual analogue score (Figure 1). Fractures were graded according to the thoracolumbar injury classification and severity scores (TLICS) and AOspine classification systems (Table 2, Figure 2).

The parameters concerning the percentage of vertebral body collapse and segmental kyphosis, were assessed by Cobb method(figure 3 and 4). Furthermore, all patients had preoperative laboratory investigations done for them; the latter included complete blood count, bleeding profile, random sugar and renal function tests, liver function tests, hepatitis and HIV scan testing.

The patients were treated with short segment posterior instrumentation; instrumentation included bilateral transpedicular screw insertion into the vertebra above the fractured one, the vertebra below and, a screw through the fracture vertebra; metal rods connected the screws bilaterally (on either side of the midline). Duration of follow-up lasted for 12 months, or more in some cases.

Internal Fixation Devices

The posterior transpedicular screw fixation system (SPINEARTR) are used in our hospital. The system is made of titanium and used for the reduction and fixation of spinal fractures. The system included polyaxial pedicle screws, connecting rods, caps, transverse bar, and reduction devices.[11]

Procedure

All surgeries were performed by the same team of Staff Neurosurgeon and their assistants. Prophylactic intravenous antibiotics were given half hour before skin incision. Patients were placed in a prone position under general anesthesia. A midline posterior longitudinal incision was used to expose one level above and below the fractured vertebra. Proper dissection was done so as to minimally damage the soft tissue around the facet joints. Pedicle screw fixation and reduction were performed under C-arm guidance.

The entry point for the pedicle was identified using these landmarks, a horizontal line drawn from the middle of the transverse processes in the lumbar vertebrae or from the junction of upper one third and lower two third of the transverse process in lower dorsal vertebrae, and a vertical line through the most prominent ridge on the corresponding superior facet (mammillary body). At the intersection of these two lines. C-arm imaging was used for accurate placement of markers. Screws were 40 or 45mm long, depending on the level and size of the vertebra. At the 10th and 11th thoracic levels, 4.5 or 5.5mm-diameter multiaxial screws and at the 12th thoracic level and caudally 5.5 mm diameter multiaxial screws were used.

Rods were then pre-contoured before insertion according to the normal sagittal alignment of the injured level. Slight distraction was done so as to gain the anterior body. In patients with a partial neurologic deficit a limited decompression was performed via a laminectomy. Direct decompression was then performed by tapping the retropulsed bone fragments into the vertebral body through a posterior approach. Cross-links were used and locking nuts were tightened over the rods. We did not routinely perform posterior fusion for patients with intact posterior column, however, if the posterior elements including facet joint or posterior ligamentous complex were found to be injured, posterolateral fusion with autogenous bone graft taken from the spinous process and lamina of the patient mixed with allograft (synthesized bone graft from spinartR). Finally, a negative-pressure catheter drain (REDIVAC drain) was applied and wound closed in layers; sterile dressing was also applied to cover the wound.

Postoperative Care and Follow Up

All patients were given intravenous analgesia (paracetamol plus tramadol) for postoperative pain control and intravenous ceftriaxone as a prophylaxis against postoperative infections. Drains were removed 24 to 48 hours postoperatively. Sutures were removed 10 to 12 days postoperatively.

Postoperative protocol for all patients includes mobilization once the pain subsided, usually on the second post-operative day. An external orthosis (hyperextension brace) was used for approximately three months postoperatively in all patients. Anteroposterior and lateral radiographs were obtained immediately after operation and at follow-up intervals of 3, 6 and final follow up at 12 months.

Successful surgery was defined as all pedicle screws firmly implanted with satisfactory reduction. Back pain was determined on the basis of Visual Analogue Scale (VAS), (Figure 1).

RESULTS:

Tables (3,4 and 5), show the demographic characteristics of all patients. There was a total of 30 thoracolumbar fracture (T10 to L2) patients 18 males (60%) and 12 females (40%), male: female ratio was 1.5:1; age ranged 15–57 years with an average of 28.86 years (SD±13). Nineteen (63.3%) patients suffered fall from height; the rest of the injuries 11 (36.6%) occurred in a road traffic accident.

Table 3. Patients' ages in years.

Age range in years	Number of patients	Means
15-57	30	28.86±13

Table 4:Patients' gender.

Gender	Number of patients (percentage)
Male	18 (60%)
Female	12 (40%)
M:F ratio: 1.5:1	

Table 5. Patterns of injuries.

Pattern of injury	Number of patients (percentage)
Fall from height	19 (63.3%)
Road traffic accident	11 (36.6%)

There were 14 patients with L1 fracture (46.6%), 10 patients with T12 (33.3%), 5 with fracture of L2 vertebra (16.6%) and 1 patient with T11 fracture (3.3%). According to the AO spine classification system, there were 13 patients with AO spine type A_3 (incomplete burst fracture), 12 patients with type A_4 (complete burst), 4 patients with type B_1 (transosseous tension band disruption) and, one patient with B_2 (posterior tension band disruption), (Tables 6 and 7).

Table 6: Vertebral level of injury.

Level of injury (vertebral fracture)	Number of patients (percentage)
First lumbar vertebra (L1)	14 (46%)
Twelfth dorsal (thoracic) vertebra T12	10 (33.3%)
Second lumbar vertebra (L2)	5 (16.6%)
Eleventh dorsal (thoracic) vertebra T11	1 (3.3%)

Table 7:Arbeitsgemeinschaft für Osteosynthesefragen (AO) spine classification of vertebral fractures.

Pattern of vertebral fracture according to AO spine classification	Number of patients
A3 incomplete burst fracture	13
A4 complete burst fracture	12
B1 transosseous tension band disruption fracture	4
B2 posterior tension band disruption fracture	1

Eleven patients had normal neurology (American Spinal Injury Association (ASIA grade E), 15 had incomplete deficits (ASIA grade B 3, C 5, D 7), and 4 patients had complete deficit (ASIA grade A). All 15 patients with incomplete neurologic deficits (ASIA B,C,D) had improvement on finalfollow-up observation, which results in 20 patients in class E, 4 patients in grade D, 3 patients in grade C and 1 patient with class B. Finally, 2 of 4 patients with complete neurologic deficit (ASIA grade A) remained unchanged. All neurologically intact patients (ASIA E) remained unchanged. No neurological deterioration was observed in this study, Table 8.

Table 8: **American Spinal Injury Association (ASIA) neurological status.**

ASIA impairment scale	Preoperative	Postoperative
A	4	2
B	3	1
C	5	3
D	7	4
E	11	20

Table 9 shows the radiological measurements. The mean segmental kyphotic angle was 21.83° before surgery (ranging from 16° to 30°, SD±4) which was significantly corrected to 4.21° three months after surgery (ranging from 0° to 10°, SD±2.65, p<0.05). The final follows up segmental kyphosis was 8.63° after one year(ranging from 4° to 13°, SD±2.74). Loss of kyphosis correction was 4.42°. The mean preoperative vertebral body collapse was 48.4% (ranging from 18.8% to 74.2%,SD±15.48), which significantly improved to 10.65% (ranging from 2% to 21.6%, SD±6.2) three months after surgery (p<0.05). The final follows up vertebral body collapse was 12.85%. Loss of vertebral height correction was 2.2%, which is insignificant (p>0.05). Most patients showed good improvement of pain and function after surgery. The preoperative pain level showed a mean VAS score of 8.55 (6 to 10, SD±1.4) which was significantly improved to 2.78, three months postoperatively, and to 0.87 at the final follow-up (p<0.05). The average point of TLICS 5.86 points.

Table 9: Radiological measurements.

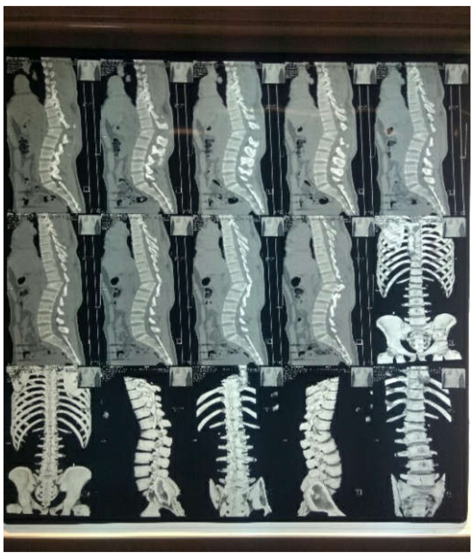
Parameter	Minimum	Maximum	Mean SD
VBC preoperative (%)*	18.8	74.2	48.4±15.48
VBC postoperative (%)	2	21.6	10.65±6.20
VBC at last follow up (%)	3	24.4	12.85±6.54
Pre-operative segmental kyphosis	16	30	21.83±4
Post-operative segmental kyphosis	0	10	4.21±2.65
Segmental kyphosis at final follow-up	4	13	8.63±2.74
VAS preoperative**	6	10	8.55
VAS postoperative	2	5	2.78 0.74
VAS at final follow up	0	2	0.87 0 67
TLICS***	4	8	5.86 8

*VBC% = Percentage of Vertebral body collapse, **VAS = Visual Analogue Scale,
***TLICS = Thoraco-Lumbar Injury Classification and Severity score.

Table 10 shows few temporal (time duration) parameters. In this series, the average injury–surgery interval was three days (range 1–7 days, SD±1.7).The mean duration of surgery was 150.66 min (120-180 min, SD± 22.27) whereas the mean blood loss was 230 mL. The mean post-operative hospital stay was 8.6 days (range 7-15 days, SD±2.31).

Table 10:Few temporal (time duration) parameters.

Parameter	Duration, mean and SD
Duration between injury and surgical intervention	1-7 days (3±1.7)
Duration of surgical procedure	120-180 minutes (150.66±22.27)
Postoperative hospital stay	7-15 days (8.6±2.31)



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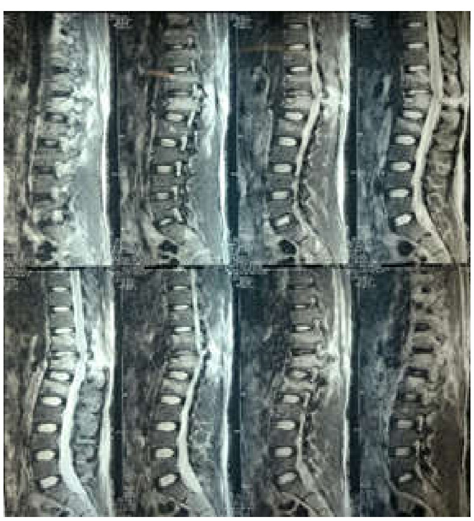

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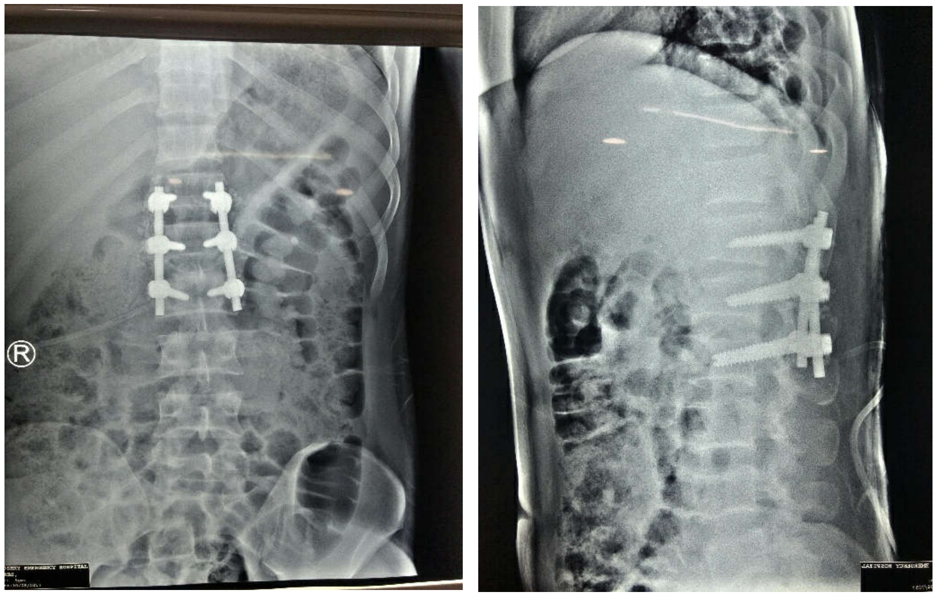

E. F.

Figure 5

Figure 5. Thoracolumbar injury case radiology. A thirty-seven-year-old male, with history of fall from height presented with thoracolumbar junction injury. Preoperative CT scan, Sagittal and 3D reconstructions (A) and axial view (B), showing AO spine type B fracture (tension band injury) of first lumbar vertebra. Magnetic resonance imaging, sagittal (C) and axial (D) T2-weighted phase of same traumatized thoracolumbar junction showing spinal canal stenosis. Post-operative plain X-ray films,lateral (E) and anteroposterior (F) showing acceptable reduction of kyphotic deformity.

DISCUSSION:

Initial fixation methods involved long fixation constructs bridging two to three levels above and two levels below the fractured vertebra. Long segment fixations are more stable but increased number of spinal levels has to be fused leading to long term back pain and restriction of motion. Hence, to preserve motion segments, shorter fusion constructs that consisted of transpedicular screws one levelabove and one level below the fractured vertebra have been advocated. However, it has been reported that traditional short segment fixation leads to poor outcome both radiologically and functionally with many instrument failures.[12] It was reported earlier that short segment fixation led to implant failure in 45% of patients within six months of operation.[13] Therefore, to augment short-segment fixation, anterior column reconstruction with adequate fixation points can be an alternate treatment method. The concept of an intermediate screw to increase the stiffness of a short-segment construct was first introduced by Docket al.[14] Farrokhi et al [15] conclude that, inclusion of the fracture level into the construct has offered better kyphosis correction, in addition to fewer instrument failures, without additional complications, and with a comparable if not better clinical and functional outcome and recommended insertion of screws into pedicles of the fractured thoracolumbar vertebra when considering a short segment posterior fixation. The majority of patients in our study were young, the mean age was around 28.86 years (age range 15-57) and out of 30 patients, 18 (60%) were male and 12 (40%) were females, This is similar to Raja et al study,[16] that young people suffer spinal injuries more often than any other age group and 86% of patients in his series of 50 patients, were males. Similarly, in other studies, Chokshi et al and Viswanathan et al, males are supposed to be more exposed to trauma than females.[17,18]. We found that fall from height was the most common cause of injury in 19 (63.3%) cases which has also been observed in Raja study but other study[19] showed road traffic accident is the common cause of injury. In our study, most common level of involved was L1 (46.6%) followed byT12 (33.3%). In the Raja study showed 46% involvement of L1 and 12% involvement of T12,coinciding almost with our results. Other studies, Ahsan et al [20] and Shetty et al,[21] also showed the common level of injury is L1. Guven et al [22] mentioned that fracture level screw fixation technique could achieve and maintain kyphotic correction. Where this technique provides the correction of deformity through vertebral endplate augmentation with its buttress effect (bending force).[23] In our study, the mean preoperative kyphotic angle was 21.83° which was significantly corrected to 4.21° three months after surgery ($p<0.05$). The final follow up segmental kyphosis was 8.63° after one year and the mean correction loss in was 4.42°. Previous studies[22,23] have shown that the mean loss of kyphosis correction ranging from 3° to 12° which is comparable to our results.

In the current series, we did not perform spinal fusion in cases with no posterior ligamentous injury and thus can preserve spinal motion segments. Our indication for posterior fusion is posterior element injuries, such as lamina, facet joint or posterior ligamentous complex injuries. It had been shown in various long term studies that fusion is not necessary to maintain the correction in kyphotic deformity in these fractures even in short segment fixation.[24] Most patients with thoracolumbar junction fractures have intact pedicles in the fractured vertebra, and this is a requirement for pedicle screw fixation at the fractured vertebra. We also did not have any difficulty in inserting screws in the fractured vertebra and agree with Kose et al [25] that the hold and pullout strength was good in all cases. We could insert screws at the fractured vertebra bilaterally except in two cases where unilateral intermediate screw was implanted as there was gross fracture of the pedicles.

Percentage of vertebral body collapse of the fractured vertebra is an index that we proposed to identify the capacity of the fractured vertebra for reduction. We found a significant difference in the loss of vertebral height of the fractured vertebra between the preoperative and postoperative values (48.4% preoperative, 10.65% early postoperative, and 12.85% at final follow up, p value < 0.05), the mean loss of correction in vertebral body collapse was 2.2%. Our results indicate that short fixation combined with intermediate screws can sufficiently decompress a compressed vertebral body, as evidenced by the early postoperative outcomes. We can postulate on the reasons for the results seen in ourreview:

First, the screw inserted into the fractured vertebra can assist in the reduction of the fractured vertebra. Many authors, [26] considered that together with the lordotically contoured rods, pedicle screw fixation at the fractured vertebra can produce a forward driving force to enhance the reduction and reshaping. Moreover, the screw inserted into the fractured vertebra can be used to directly raise the end plate to assist in the restoration of the compressed vertebral height[27]. Second, short-segmental fixation combined with intermediate screws can improve the stress distribution of the internal fixation system and protect the uninjured vertebra and intervertebral disk. Some studies suggest kyphosis resulting from thoracolumbar fractures occurs mainly in the disk, and it is the change in the intervertebral space, rather than the vertebral collapse, that induces the kyphosis.[28] Finally, there may be a vertebral body filling effect. Because vertebral compression results in trabecular bone destruction, a cavity is produced within the vertebral body after reduction, which may induce vertebral re-collapse postoperatively. A pedicle screw inserted into the fractured vertebra can fill this cavity, which can result in better reduction of the fractured vertebra. Currently, there is no research that supports this view, and further studies are required.[29]

In this study, all 15 patients with incomplete neurologic deficits (ASIA B,C,D) had neurologic improvement on final follow-up observation, which results in 20 patients in grade E, 4 patients in grade D, 3 patients in grade C and 1 patient with grade B, and 2 of 4 patients with complete neurologic deficit (ASIA A) remained unchanged. All neurologically intact patients (ASIA E) remained unchanged. No neurological deterioration was observed in this study.

Most patients showed good improvement of pain and function after surgery. The preoperative pain level showed a mean VAS score of 8.55 (6 to 10, SD±1.4) which was significantly improved to 2.78, three months postoperatively, and to 0.87 at the final follow-up ($p<0.05$). Many surgeons believe that kyphotic deformity of the thoracolumbar spine precipitates poor clinical outcomes,but the relationship between these two factors is unclear. Some authors advocate that there is no proven association between kyphosis and back pain or functionalimpairment.[30]

CONCLUSION:

The present study has demonstrated that unstable thoracolumbar junction fractures, in patients with or without neurologic deficits can be decompressed and stabilized with posterior short-segment instrumentation including the fractured vertebra, through a single posterior approach. Short-segmental fixation combined with intermediate screws effectively restored fractured vertebral height and also was associated with a significant decrease in the segmental kyphotic angle, in addition to the improvement in clinical outcomes.

Recommendations

There are some limitations of our study as the study population is small, so we recommend larger population. Moreover, a comparison study with long or traditional short segment should raise the validity of intermediate screw. Long-term follow-up with co-morbid factors considerations is required to assess the outcome of surgery.

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